Modeling and Evaluation of Bi-Static Tracking in Very Shallow Water

Stewart A.L. Glegg
Dept. of Ocean Engineering
Florida Atlantic University
Boca Raton, FL 33431
phone: (954) 924 7241 fax: (954) 924-7270 e-mail: glegg@oe.fau.edu

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LONG TERM GOALS

Improve passive acoustic tracking capabilities in shallow water by extending the concepts developed to date for the ANS sonar system, and developing an acoustic model for AUV mission planning and data assessment.

OBJECTIVES

1) Build and test a two man deployable autonomous passive sonar (SQUID) to add a bi-static capability to the Ambient Noise Sonar (ANS).

2) Develop acoustic models for tracking error estimation, reduction and evaluation.

3) Experimentally calibrate and evaluate the acoustic model and the sonar in very shallow water as it pertains to a typical AUV operation.

4) Experimentally evaluate bi-static tracking and modem signature distortion in varying surface wave conditions and directions.

5) Develop, and evaluate at sea, an environmentally based numerical model which predicts frequency selective fading and surface Doppler effects on acoustic tracking and performance.

APPROACH

To achieve the multiple objectives of this project the approach has been broken down into three principle tasks (1) design and build of a two man deployable array (2) development of numerical models, and (3) experimental testing and evaluation of systems and models in the SFTF range. The majority of the work was completed in FY01, this report will describe the additional work on numerical modeling which was completed in FY02.

WORK COMPLETED

1) An integrated coastal ocean and acoustic propagation model has been implemented to determine the effects of the ocean variations on acoustic propagation in the SFTF range. The ocean dynamics were modeled using the Princeton Ocean model with forcing conditions that included tides, river run off,

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14. ABSTRACT
Improve passive acoustic tracking capabilities in shallow water by extending the concepts developed to date for the ANS sonar system, and developing an acoustic model for AUV mission planning and data assessment.

15. SUBJECT TERMS

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wind and realistic bottom topography. Boundary conditions which represented the effect of the Gulf stream were used, based on ADCP measurements taken by a ship transiting around the outer edge of the region of interest (Figure 1). The sound velocity profiles which were calculated by the model were used as inputs to the range dependent parabolic acoustic propagation model RAM. The results show that the fluctuations in ocean conditions cause scintillation in the acoustic propagation field as described below.

2) Additional experimental work was carried out using the ANS sonar systems during the Fall of 2001. The two systems developed as part of this project were deployed at the same time to investigate bi-static passive tracking and twelve new data sets were obtained providing data for a variety of different conditions.

RESULTS

1) The numerical model calculated the oceanographic condition in the region of the SFTF shown in Figure 1.

Figure 1: The area chosen for the numerical study that is part of the SFTF range off Port Everglades, Florida

The inputs to the oceanographic model were obtained from experimental measurements on three consecutive days in July 2001. The oceanographic model was run for up to eight days and provided a time history of the ocean currents in the region and the sound velocity profile as shown in Figure 2. Significant variations were found in both space and time as shown in the figure. Some internal wave action was calculated and found to affect the sound propagation and movies are available showing the time and space variation of the current and sound velocity profile.

The sound field from a number of different source locations was obtained using the RAM acoustic propagation model, and a typical example is shown in Figure 3. This shows the propagation from a

source in 20m of water on the shelf, and the sound field offshore. The results indicate that the acoustic waves are trapped near the bottom and that there is a shadow zone closer to the surface at a range of 4 km from the source.

Also calculated was the scintillation index that was obtained by averaging the sound field as the oceanographic conditions changed as a function of time. The results showed that the fluctuations at high frequencies were uniformly distributed and varied at time by as much as ±3dB.

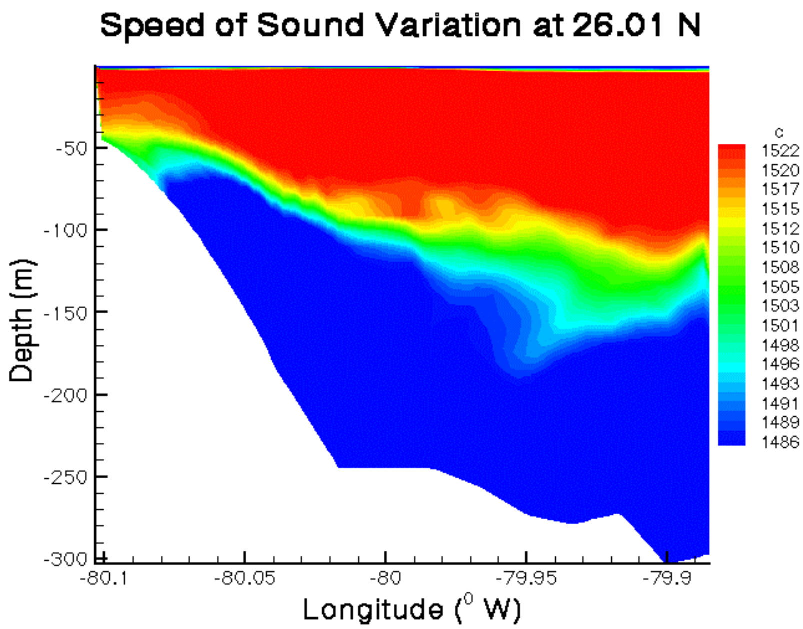

Figure 2: The spatial variation of the sound velocity profile calculated by the oceanographic model.

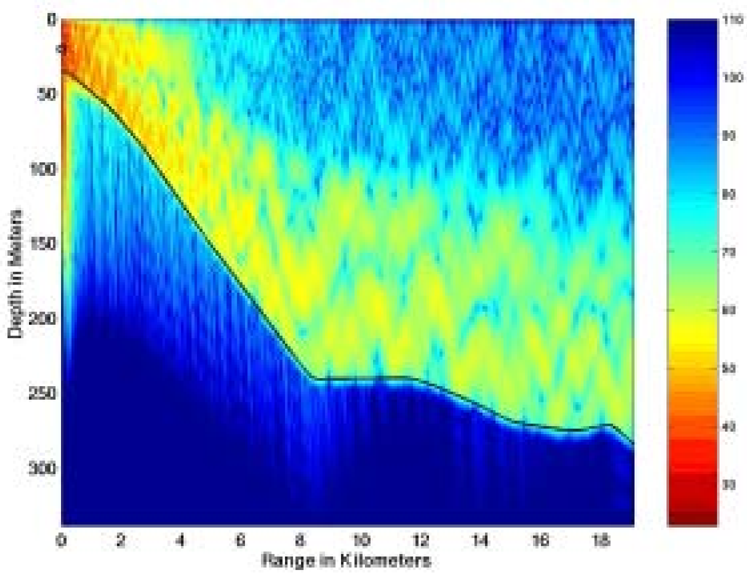

Figure 3: The Sound field from a 200Hz source at 20m depth propagating in the offshore direction in the SFTF range

2) During the experimental tests of the passive sonar systems both passive arrays were fixed to the bottom to eliminate errors due to dynamic heading, pitch and roll. During this test it was found that bearing track blackout periods occurred at times, lasting for several minutes. During these periods, very low signal to noise ratios caused the tracking of the source to be inaccurate yielding bearing angles that did not adhere to the bearing track. The duration of these blackout periods could be several minutes. It is interesting to note that the expected signal was captured sparsely, although much of the data during these periods was not usable. However, for those samples with SNRs within an acceptable range, both the required signal and interfering signals from boats and noise sources appeared in the time history.

IMPACT

The numerical calculations of the sound field in the SFTF range and it's variation with oceanographic conditions will be important for the Ocean Acoustic Observatory which will be located at this site.

RELATED PROJECTS

This project is part of the effort by the SFOMC partnership.